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**FINAL REPORT
TESTS ABLE AND BAKER**

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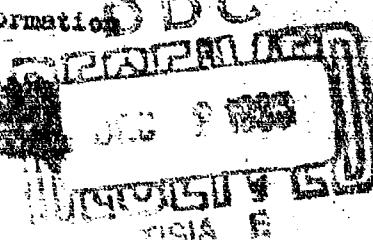
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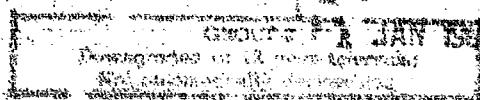
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REG. NO. 10



S-E-C-R-E-T

(1) DAMAGE TO MARITIME COMMISSION BUILT VESSELS OF THE
TARGET ARRAYS OF THE ATOMIC BOMB TESTS 'ABLE' ON JULY 1, 1946
AND 'BAKER' ON JULY 25, 1946 AT BIKINI ATOLL, MARSHALL ISLANDS

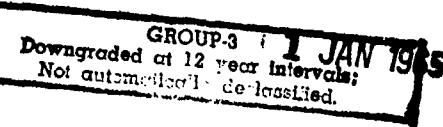
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COPY NO. 62

This page discusses the

~~REPORT OF DAMAGE TO MARITIME COMMISSION BUILT VESSELS OF THE
TARGET ARRAYS OF THE ATOMIC BOMB TESTS "ABLE" ON JULY 1, 1946
AND "BAKER" ON JULY 25, 1946 AT BIKINI ATOLL, MARSHALL ISLANDS.~~

GENERAL

The Maritime Commission built vessels of the test Able target array consisted of 19 transport attack ships of the S4 - SE2 - DD1 design, and two concrete barges of the B7 - A2 design. Of these 21 vessels two transport attack ships were sunk and the others suffered varying degrees of damage hereafter described.

The vessels of Commission construction used in the test Baker target array consisted of 17 of the above transport attack ships and the same two concrete barges. One of the concrete barges was sunk. Damage to the other 18 vessels was as hereafter described.

This report is of necessity limited in scope from the technical standpoint because such data as the maximum blast pressures, air velocities, underwater pressures, ocean wave lengths and amplitudes, ships motions and temperatures enveloping the target vessels are unavailable at the present time. It is recognized that without the necessary data to give a complete picture of the bomb action on the entire target array the important objectives for improved ship construction may be missed for merchant vessels. As an example, the evaluation of the structural damage sustained by other categories of vessels located at approximately the same distance from the explosion center as the merchant type will give a clue as to which system of hull construction can best resist the forces of the blast. This determination of the "critical scantling;" is needed before we can even consider what improvements should be incorporated in future merchant hull construction.

These data and other related information no doubt will be the subject of comprehensive reports on tests Able and Baker to be issued by the Joint Chiefs of Staff at some later date. Copies of these reports should be made available to the Maritime Commission. However the information at hand which was obtained by visual inspection and analysis is believed to be of sufficient immediate importance to warrant its early study toward possible improvement of merchant ship design.

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TARGET ARRAY COMPOSITION FOR TEST ABLE

The cluster of ships anchored within the Bikini lagoon constituted the target array, which was made up of 88 vessels, representing many types of fighting ships and auxiliaries including transport attack ships. This array was arranged in the form of a wheel with an inner circle of approximately 300 yards in diameter for the hub and lines of ships projecting outward radially from it like spokes. This arrangement permitted the evaluation of graduated damage from the center of the target. Within the inner circle there were anchored nine vessels. About 25 ships or 28% of the total target was concentrated within 1,000 yard circle from the NEVADA, the center of the target, and of this number 35% consisted of Maritime Commission built ships.

TARGET ARRAY COMPOSITION FOR TEST BAKER

The target array for test Baker was arranged similarly to the array for test Able except for changes hereafter noted. The inner target circle of approximately 500 yards in diameter had for its center the bomb carrying vessel, the LSM 60. On the periphery of this circle were anchored the most central target vessels. Roughly 19 vessels or 22% of the target array were anchored within 1,000 yard circle of the LSM 60, the center of the target, and of this number 26% consisted of Maritime Commission built ships. There were lines of ships projecting radially outward from the inner circle of ships. As in test Able two of those radially outward projecting lines of ships were made up of transport attack vessels, APA's.

DAMAGE SUSTAINED IN TEST ABLE.

The atomic bomb dropped over the target array on July 1, 1946 was intended to burst in the air over the target center which was represented by the battleship USS NEVADA. Due to conditions beyond human control the bomb did not explode over the exact center of the target. In consequence it was not possible to attain fully the graduated symmetrical damage sought for the two spokes of the target wheel composed of transport attack ships.

Five vessels were sunk by the burst. These vessels were: the transport attack vessels USS CARLISLE and USS GILLIAM, and the destroyers USS ANDERSON and USS LAMSON, and the Japanese cruiser SAKAWA. The GILLIAM apparently sank immediately. The aerial photos show the CARLISLE for the last time in a burning and badly damaged condition four minutes after the burst. The cruiser SAKAWA rolled over and sank approximately 26 hours later.

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The result of the Atomic Bomb exploding in air over the target array of Test Able, other than the five vessels sunk, indicated widespread topside damage with its intensity diminishing rather steeply from ship to ship with increasing distance from the center of the burst. Moderate to severe damage was sustained by six vessels all within the wheel hub of the array, and superficial to moderate damage by a much larger number of vessels on the radial spokes of the target array.

The graduated damage sustained by the transport attack ships is presented briefly in Appendix No. 1, which in addition includes the approximate relative bearing and distance of the vessel from the bomb burst. Appendix No. 1 is arranged in two parts: one covering the west sector of the target array of APA vessels; and the other covering the southeast sector of APA vessels.

DAMAGE SUSTAINED IN TEST BAKER.

The underwater explosion that took place on July 25, 1946 resulted in the sinking of seven vessels which were: the battleship U.S.S. ARKANSAS and the bomb carrying LCM both of which went down immediately; two submarines; the concrete barge YOG 160; the carrier U.S.S. SARATOGA; and the Japanese battleship NAGATO. The SARATOGA sank approximately 8 hours after the burst and the NAGATO sank several days after the burst. Severe damage that probably would have resulted in their eventual sinking was suffered by the transport ship U.S.S. FALLOON, the destroyer U.S.S. HUGHES. Those two vessels were towed out from the array and beached. Because of the intense radioactivity present on most of the target ships their graduated damage sustained has not been fully evaluated. As of August 1, 1946 only five of the APA vessels have been safe to fully inspect. These vessels were located at the extreme outer periphery of the array (See Appendix 2) and suffered no damage. It is anticipated that inspections of the remainder of the APA vessels will be delayed for some unknown time.

RADIOLOGICAL EFFECTS.

It is probable that one of the most important phases of the atomic bomb as a weapon is the residual radioactivity in the immediate area subjected to the blast. Information of this phase of the bomb is not available. It may suffice to say that radioactivity either induced in water, metal, or other material by neutron bombardment or from small bits of the products of fission from the bomb itself, while dissipating rapidly, slows down salvage operations to the point of ships being lost that otherwise could be saved. Personnel casualties because of residual radioactivity or direct neutron bombardment while not immediate would in the course of time be great even for vessels beyond the circle of extensive structural damage, from such a blast.

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The following recommended studies based on inspection of the target vessels of both tests and analysis of the damage, are made on the assumption that future merchant ship construction should embody some protection against atomic bomb blast.

1. Details of joints for important structural elements should be designed to accommodate some reversal in loadings. This applies to brackets joining deck beams and side shell frames primarily.
2. All fillet welds made on important structural elements should be of the deep penetrating type. Study should be made towards modifying the details of attachment to permit developing of the full strength of the weld.
3. Pontoon hatch covers should be redesigned towards preventing their being blown off the hatch during the negative pressure phase, that follows a blast. Provision should be made also to secure hatch covers in position in such a way as to prevent their falling into the hold below when severely distorted.
4. Strong backs resting on the longitudinal hatch coaming girder system should be given more bearing area to prevent local crumpling and should be provided with means to retain them in position when severely distorted.
5. Study should be made of the access openings in bulkheads towards developing a door and framing unit that have the same strength and stiffness as the bulkhead proper.
6. Internal joiner bulkheads of the built up sections riveted type should have either more rivet area to hold sections together, or preferably should embody a more effective joint. Welded light gauge plating seems to offer a good possibility.
7. The grillage framing system in way of cargo openings should be redesigned for increased stiffness and strength. Provision should be made for a portable stanchion arrangement that could be installed in war time to lessen damage that may result from too severe deck deflections.
8. The superstructure should present as much curved surface as possible to an air blast. Vertical ladders should have more bracket supports, and some intermediate support rest for the booms should be provided when stowed in the horizontal position.

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9. Stacks should be designed with some margin against premature collapse of the light plating. Square vent openings should be eliminated. The joint connection of the stack to the top of the house should be improved so as to prevent the stack from being blown sidewise and damaging the inner casings and uptakes. Manner of staying the inner casings to the stack should be re-examined.
10. Boiler uptakes should be redesigned to avoid flat surfaces and square corners where ever possible.
11. Important pipe lines such as the fire mains should not be fastened to decks in danger of distortion when subjected to a bomb blast. This applies in particular to the unsupported decks in holds around the cargo hatches.
12. Study should be made of the gravity type boat davits towards eliminating or more rigidly supporting the heavy pendulous beam from which the boat hangs; also protecting the cables from being kinked in a blast or sudden shock.
13. Bronze or aluminum binnacles should be installed on all weather or upper deck steering stations in place of the wooden binnacles. The latter splinter easily.
14. Cast steel in place of cast iron should be used in the machine tools of the engineers machine shop as an added precaution against damage from shock.

DATE August 3, 1946

SUBMITTED BY:

/s/ John Vasta
John Vasta
Assistant Chief Research Section

/s/ R. M. Meyer
R. M. Meyer
Naval Architect

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APPENDIX I

DAMAGE SUSTAINED BY TARGET VESSELS OF MARITIME COMMISSION CONSTRUCTION - TESTABLE

WEST LINE OF APA TRANSPORT ATTACK VESSELS

APA 57 U.S.S. GILLIAM.

The bomb burst approximately 65 yards in plan and at a relative bearing of 20 degrees. The damage was such that the vessel sank within one minute after the burst.

APA 69 U.S.S. CARLISLE.

The bomb burst approximately 400 yards in plan and at a relative bearing of 291 degrees from this vessel. It was last seen four minutes after the burst, burning and in a badly damaged condition.

APA 77 U.S.S. CRITTENDEN.

This vessel was the most severely damaged of the APA class afloat after test Able. The upper deck region in way of No. 1 hold was deflected 18 inches causing the beam system below to suffer considerable distortion; hatch girder and end beams were bent and twisted; shell on starboard side buckled full panel lengths between frames in area of No. 1 hold; starboard side main deck and first platform bent down 15 inches and 4 inches respectively; shell frames port and starboard above main deck distorted, crumpling, and in some cases cracking the triangular brackets that connected them with deck beams; transverse bulkheads in No. 1 cargo hold above main deck dished in 5 inches bending vertical stiffeners; severe distortion at joints of longitudinal hatch girder with transverse bulkhead deep stiffeners causing web of stiffener to fail showing shear wrinkles $2\frac{1}{2}$ inches in depth. The upper deck in way of No. 2 cargo hold deflected about 6 inches as was also the dock below but to a lesser degree. All pontoon hatch covers on upper and main decks were bent, distorted, and found on the bottom of the holds, as were also the hatch cover strong backs. Superstructure decks and plating were buckled 1 to 2 inches in depth, and bulwark plating at upper elevations dished. Weather doors were either torn from hinges or severely distorted. All metal joiner work, furniture and ventilation ducts in way of cargo holds were damaged badly. All top masts and cargo booms except aft port boom were bent. Radiant heat from a point 346 degrees relative bearing caused blistering and scorching of painted surfaces. Exposed lines were scorched. Both outer stack casings were crushed and bent in. The after inner stack casing had a hole 18 inches by 4 inches torn in it.

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There were cracks in the outer casings that extended out from the sharp corners of the stack ventilation openings. Staybolts between outer and inner casings of both stacks pulled holes in inner casings. Casing of No. 1 boiler was split where welded to the uptake casing, and there were 4 inch splits at each corner. Three of the four Welin boat davits were made inoperable because of structural damage. The fire main was broken at the flanges in three places due to deck deflections. Lighting and fire alarm circuits in both cargo holds were inoperable. Two searchlights, one signal light, and three gyro repeaters were damaged. Approximate range from the bomb burst in plan was 550 yards from the bow.

APA 79 U.S.S. DAWSON.

Structural damage consisted of: upper dock dished down 4 inches on each side of No. 1 cargo hold; main deck at No. 1 cargo hold deflected down 2 inches; superstructure decks and bulkheads dished moderately; forward pilot house bulkhead dished in five inches; longitudinal bulkhead inboard of the port Well Deck buckled about 3 inches. Weather doors on port side were distorted. Main topmast and forward 15 ton cargo boom were bent. Upper dock hatch covers pushed into hold causing supporting strong backs to shear pins and fall to space below. All pontoon hatch covers of main deck were distorted. Outer casings of both stacks were badly crushed. Paint heavily scorched by radiant heat coming from a point 320 degrees relative. A manila hawser and a mattress were burned. Structural damage caused failure of minor electrical circuits. Wire rope falls of No. 2 Welin davit were damaged. No. 4 Welin davit was damaged structurally. The approximate range in plan from the bomb burst was 816 yards from the bow.

APA 66 U.S.S. BRULE.

Weather doors and hatches were left open on this vessel. Structural damage consisted of: slight dishing of shell forward on the starboard side at upper deck level; superstructure bulkheads on starboard side were generally dished with diminishing intensity from forward to aft; all interior joiner bulkheads were distorted and those in way of openings to weather deck were torn from their connections. Cargo booms on starboard side were slightly bent. Radiant heat from a point 122 degrees relative bearing caused heavy scorching of paint and exposed cordage. Two swab racks were burned. Starboard boat davit motor controllers were damaged by shock. Oil ring of a ship's service generator was knocked out of its groove causing failure of the bearing. The cast iron column of engineers drill press was broken at the base. The outer casings of both stacks were dented in and crushed. The inner casings were not damaged. The approximate range from the bomb burst was 990 yards from the bow.

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APA 61 U.S.S. BARROW.

Structural damage consisted of buckling the shell just forward of No. 1 hold on port side between main and platform decks about 4 inches in depth and dishing in of panels on superstructure on port side. Weather doors sustained some distortion. Pontoon and upper deck hatch covers were lifted and dropped into the holds. One 5 inch hawser was ignited and caused minor electrical damage. Three cargo lights and one 24 inch searchlight were damaged. Forty light bulbs were broken. Outer casings of both stacks were slightly dented. The approximate distance of the bow of this vessel from the bomb burst was 1,300 yards, and the relative bearing was 317 degrees.

APA 68 U.S.S. BUTTE.

The outer stack casings were slightly dented. Radiant heat coming from a point 309 degrees relative caused blistering of paint and scorching of exposed lines and cordage. Two fires were started one of which caused an acetylene cylinder to explode damaging life rafts; the other fire did minor damage to the radar control station. Several minor electrical circuits were damaged and a few light bulbs were broken. The approximate distance of the bow of this vessel from the bomb burst was 2,008 yards.

APA 85 U.S.S. GASCONADE.

Slight dishing of locker on port bridge wing. A number of hatch covers from both cargo hatches were lifted and dropped in the holds. Radiant heat coming from a point 302 degrees relative bearing caused slight scorching of paint on port side of shell forward. The approximate distance of the bow of this vessel from the bomb burst was 2,783 yards.

APA 75 U.S.S. CORTLAND

Radiant heat from a point 300 degrees relative bearing caused extensive scorching of exposed cordage and started a fire which destroyed two LCVP boats at No. 2 boat davit. This fire spread to the officers quarters and wardroom damaging pieces of furniture and causing minor electrical and structural damage in this area. The approximate distance of the bow of this vessel from the bomb burst was 3,212 yards.

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SOUTHEAST LINE OF APA TRANSPORT ATTACK VESSELS.

APA 60 U.S.S. BANNER.

Structural damage consisted of dishing of starboard and aftor bulkheads on the superstructure. The bulwark on starboard side was bent. Five weather doors were distorted and inoperable. Upper deck hatch covers were bent and fell into the spaces below. Strongbacks under hatch covers failed. General distortion of joiner bulkheads and lockers in hold areas. Radiant heat from 160 degrees relative caused paint on vertical surfaces to blister and scorch. Exposed lines, signal halyards, and flag bag burned. The mounting of a searchlight and a number of light bulbs were broken. Outer casings of both stacks were dented. The approximate distance of the bow of this vessel from the bomb burst was 1,250 yards.

APA 81 U.S.S. FALLON.

Structural damage consisted of slight dishing of the shell plating forward on port side main deck level, port side and aftor bulkheads of the superstructure. The weather doors were distorted. Half of upper deck hatch covers on No. 2 cargo hatch were bent and twisted. All items on superstructure of light plating were badly distorted. Outer casing of the after stack was slightly dented. Controller panel of No. 2 cargo winch was broken. Radiant heat from 195° relative bearing started fires in the Army clothing exposed on deck. Exposed swabs burned. The approximate distance of the bow of this vessel from the bomb burst was 1,360 yards.

APA 65 U.S.S. BRISCOE.

Structural damage consisted of slight dishing of transverse bulkheads at the after end of the superstructure. Hatch covers of both holds were lifted and dropped from the upper deck to the main deck. Radiant heat from a point 185° relative bearing caused paint to blister on vertical surfaces. Cordage was scorched. A fire destroyed No. 2 hatch tarpaulin. The aftor stack was slightly dented. The approximate distance of the bow of this vessel from the bomb burst was 1,650 yards.

APA 70 U.S.S. CARTERET.

Superstructure bulkheads suffered some dishing. Weather doors were distorted. Some of cargo hatch covers of hatches No. 1 and No. 2 were lifted and dropped into the holds. Radiant heat from a point 140° relative bearing caused paint damage to vertical surfaces. Exposed cordage and fire hose was scorched. A bundle of clothing burned on deck. Several light bulbs were broken. Both stacks were dented. The approximate distance of the bow of this vessel from the bomb burst was 1,670 yards.

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APA 71 U.S.S. CATRON.

There was slight dishing of the after transverse bulkheads of the superstructure. Hatch covers of both hatches were displaced and dropped into the holds. Radiant heat from a point 189° relative bearing blistered paint on vertical surfaces and caused one rubberized cloth weather jacket which was exposed, to burn. The after stack was slightly dented. The approximate distance of the bow of this vessel from the bomb burst was 1,840 yards.

APA 64 U.S.S. BRACKEN.

There was general dishing of lighter plating on the superstructure. Lower part of the after stack was dished. Six light bulbs were broken. Radiant heat from a point 205° relative bearing scorched and blistered paint surfaces. Exposed cordage was scorched. Three halyards and a canvas covered chafing gear were burned. The approximate distance of the bow of this vessel from the bomb burst was 2,315 yards.

APA 83 U.S.S. FILLMORE.

Port flag bag was slightly dished. Hatch panel covers for No. 2 cargo hold were lifted and dropped in the hold. Slight damage was done to a 500 watt flood light. Radiant heat coming from a point 212° relative bearing blistered the paint slightly and scorched exposed cordage. The approximate distance of the bow of this vessel from the bomb burst was 2,450 yards.

APA 63 U.S.S. BLAIDEN.

The stack ventilator screens, and two locker covers were blown off. About one-third of the hatch covers of No. 1 and No. 2 cargo hatches were lifted and dropped into the holds. Heat radiation from a point 216° relative bearing caused slight damage to paint on vertical surfaces. Lines were scorched and a rope fender, a halyard and several swabs burned. The approximate distance of the bow of this vessel from the bomb burst was 2,770 yards.

APA 86 U.S.S. GENEVA.

Slight dishing of the joiner bulkhead at the main dock level forward, bulkhead at foot of ladder port side amidships house. Several hatch covers dropped in No. 1 and No. 2 holds. Paint on vertical surfaces and exposed lines were slightly scorched. Jute cargo net on port side burned. The radiant heat came from a point 220° relative bearing. The approximate distance of the bow of this vessel from the bomb burst was 3,028 yards.

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APA 87 U.S.S. NIAGARA.

The port flag bag was slightly dished. Several hatch covers were lifted and dropped into the cargo holds. Radiant heat from a point 222 relative bearing caused slight singeing of exposed lines. An oil soaked rope fender caught fire and burned causing damage to minor electrical circuits. The approximate distance of the bow of this vessel from the bomb burst was 3,235 yards.

DAMAGE TO THE CONCRETE BARGES.

YOG 83

Wooden wheel house twisted, some of its boards blown off. The forecastle was blown down. Few transverse concrete beams of the pump house amidships were cracked. Miscellaneous light topside items blown off foundations. Radiant heat blistered and scorched paint. The pressure wave came from a point 140 degrees relative bearing. The approximate distance of the bow of this vessel from the bomb burst was 1,067 yards.

YOG 160.

Extensive superstructure damage was caused by the blast. The catwalk, pump and boiler house amidships, and the poop house were demolished. Forecastle resisted the blast but suffered extensive panel deflections and cracking of concrete. The wooden bridge house aft burned. Local damage to main deck by falling equipment. Machinery in amidships house inoperative due to shifting on foundations. All other machinery inoperable except anchor windlass. Electrical circuits were damaged. Heat radiation was from a point about 195 degrees relative bearing. The approximate distance of the bow of this vessel from the bomb burst was 540 yards. The concrete hull remained intact and watertight.

APPENDIX 2.

DAMAGE SUSTAINED BY TARGET VESSELS OF MARITIME COMMISSION CONSTRUCTION - TEST BAKER.

APA 81 U.S.S. FALLON.

This vessel, at a distance of approximately 500 yards, was the closest of the APA's. Observations made from a safe distance as the ship was being towed to shallow water revealed a severe list to the starboard with an approximate freeboard of 3 feet to the main deck aft. The forward starboard boom was lying transversely across the deck together with some broken rigging. The port forward wing corner of the house appeared to have been twisted forward. A couple of ladders were broken. The starboard side shell plating at about the aft quarter point appeared to have suffered severe dishing.

NAME OF VESSEL	APPROXIMATE RANGE	EXTENT OF DAMAGE
APA 75 U.S.S. CORTLAND	3,600 yards	None
APA 87 U.S.S. NIAGARA	3,200 "	"
APA 86 U.S.S. GENEVA	2,800 "	"
APA 63 U.S.S. BLADEN	2,400 "	"
APA 83 U.S.S. FILLMORE	2,000 "	"

NOTE:

The other 12 Maritime Commission built vessels have not been inspected as of this date, August 1, 1946 because of the intense radioactivity.



Defense Special Weapons Agency
6801 Telegraph Road
Alexandria, Virginia 22310-3398

TRC

18 April 1997

MEMORANDUM FOR DEFENSE TECHNICAL INFORMATION CENTER
ATTENTION: OMI/Mr. William Bush (Security)

SUBJECT: Declassification of Reports

The Defense Special Weapons Agency has declassified the following reports:

- ✓AD-366588 L XRD-203-Section 12 ✓
- AD-366589 L XRD-200-Section 9
- AD-366590 L XRD-204-Section 13
- AD-366591 L XRD-183
- ✓AD-366586 L XRD-201-Section 10 ✓
- ✓AD-367487 L XRD-131-Volume 2 ✓
- ✓AD-367516 L XRD-143 ✓
- ✓AD-367493 L XRD-142 ✓
- AD-801410L ✓ XRD-138
- AD-376831L ✓ XRD-83
- AD-366759 L XRD-80
- ✓AD-376830L L XRD-79 ✓
- ✓AD-376828L L XRD-76 ✓
- ✓AD-367464 L XRD-106 ✓
- AD-801404L ✓ XRD-105-Volume 1
- ✓AD-367459 L XRD-100 ✓

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✓ AD-367517 X	XRD-141 ✓
AD-366762 ✓	XRD-84
AD-366760 ✓	XRD-81
AD-366761 ✓	XRD-82
AD-367501 ✓	XRD-158-Volume 1
AD-367507L ✓	XRD-152-Volume 4
AD-367495 X	XRD-184 ✓
AD-367485 X	XRD-129 ✓
AD-367484 X	XRD-128 ✓
AD-367483 X	XRD-127 ✓
AD-367482 X	XRD-126 ✓
AD-367488 ✓	XRD-132
AD-367480 X	XRD-124 ✓
AD-801409L ✓	XRD-135
AD-367490 X	XRD-136 ✓
AD-367492 X	XRD-137 ✓
AD-801411L ✓	XRD-139
AD-367518 X	XRD-140 ✓
AD-367515 ✓	XRD-144
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AD-367468 X	XRD-110-Volume 2 ✓
AD-367513 ✓	XRD-146
AD-367497 X	XRD-162 ✓

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18 April 1997

Subject: Declassification of Reports

AD-801406L ✓ XRD-114.

In addition, all of the cited reports are now **approved for public release; distribution statement "A" now applies.**

Ardith Jarrett
ARDITH JARRETT
Chief, Technical Resource Center